# Evaluation of Sorbent Injection for Mercury Control

Quarterly Technical Report
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# ABSTRACT

The power industry in the U.S. is faced with meeting new regulations to reduce the emissions of mercury compounds from coal-fired plants. These regulations are directed at the existing fleet of nearly 1,100 boilers. These plants are relatively old with an average age of over 40 years. Although most of these units are capable of operating for many additional years, there is a desire to minimize large capital expenditures because of the reduced (and unknown) remaining life of the plant to amortize the project. Injecting a sorbent such as powdered activated carbon into the flue gas represents one of the simplest and most mature approaches to controlling mercury emissions from coal-fired boilers.

The overall objective of the test program described in this quarterly report is to evaluate the capabilities of activated carbon injection at five plants with configurations that together represent 78% of the existing coal-fired generation plants. This technology was successfully evaluated in NETL's Phase I tests at scales up to 150 MW, on plants burning subbituminous and bituminous coals and with ESPs and fabric filters. The tests also identified issues that still need to be addressed, such as evaluating performance on other configurations, optimizing sorbent usage (costs), and gathering longer-term operating data to address concerns about the impact of activated carbon on plant equipment and operations. The four test sites identified in the original contract were Sunflower Electric's Holcomb Station, AmerenUE's Meramec Station, AEP's Conesville Station, and Detroit Edison's Monroe Power Plant. Baseline and parametric testing at a fifth site, Missouri Basin Power Project's Laramie River Station Unit 3, was made possible through additional cost-share participation targeted by team members specifically for tests at Holcomb or a similar plant.

This is the eleventh quarterly report for this project. Parametric testing was conducted at Conesville during this reporting period. An overview of these results is included in this report.

In general, quarterly reports are used to provide project overviews, project status, and technology transfer information. Topical reports will be prepared for each test site and these will include detailed technical information.

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# INTRODUCTION

The overall objective of this test program is to evaluate the capabilities of activated carbon injection at five plants with configurations that together represent 78% of the existing coal-fired generation plants. Activated carbon injection was successfully evaluated in NETL's Phase I tests at scales up to 150 MW on plants burning subbituminous and bituminous coals and with ESPs and fabric filters. The tests also identified issues that still need to be addressed, such as evaluating performance on other configurations, optimizing sorbent usage (costs), and gathering longer-term operating data to address concerns about the impact of activated carbon on plant equipment and operations. A summary of the key descriptive parameters for the host sites can be found in Table 1. Laramie River Station was added as the fifth site in the program during 4Q04.

The technical approach that is being followed during this program allows the team to: 1) effectively evaluate activated carbon and other viable sorbents on a variety of coals and plant configurations, and 2) perform long-term testing at the optimum condition for at least one month. These technical objectives will be accomplished by following a series of technical tasks:

Task 1. Design and Fabrication of Sorbent Injection System

Task 2. Site-Specific Activities including Field-Testing

Task 3. Technology Transfer

Task 4. Program Management and Reporting

Tasks 1, 3, and 4 are intended to support the overall direction, implementation, technology transfer, and management of the program. Task 2 will be repeated for each test site with subtasks designed to address the specific configurations, needs, and challenges of that site. Task 2 is the heart of the program and contains subtasks to address each important component of the testing. A summary of the Field-Testing (Task 2) subtasks is presented in Table 3.

**Table 1. Host Site Key Descriptive Information.**

| | **Holcomb** | **Meramec** | **Laramie River** | **Monroe** | **Conesville** |
|---|---|---|---|---|---|
| Test Period | 3/04–8/04 | 8/04–11/04 | 2/05–3/05 | 3/05–6/05 | 3/06–5/06 |
| Unit | 1 | 2 | 3 | 4 | 6 |
| Size (MW) | 360 | 140 | 550 | 785 | 400 |
| Coal | PRB | PRB | PRB | PRB/Bit blend | Bituminous |
| Particulate Control | Joy Western Fabric Filter | American Air Filter ESP | ESP | ESP | Research-Cottrell ESP |
| SCA ($ft^2$/kacfm) | NA | 320 | 599 | 258 | 301 |
| Sulfur Control | Spray Dryer Niro Joy Western | Compliance Coal | Spray Dryer | Compliance Coal | Wet Lime FGD |
| Ash Reuse | Disposal | Sold for concrete | Disposal | Disposal | FGD Sludge Stabilization |
| Test Portion (MWe) | 180 and 360 | 70 | 140 | 196 | 400 |
| Typical Inlet Mercury (μg/dNm$^3$) | 10–12 | 10–12 | 10–12 | 5–10 | 15–30 |
| Typical Native Mercury Removal | 0–13% | 15–30% | <20% | 10–30% | 50% |

A detailed topical report will be prepared for tests conducted at each test site. Quarterly reports will be used to provide project overviews, status, and technology transfer information.

# EXECUTIVE SUMMARY

This five-site project is part of an overall program funded by the Department of Energy's National Energy Technology Laboratory (NETL) and industry partners to obtain the necessary information to assess the feasibility and costs of controlling mercury from coal-fired utility plants. Host sites that will be tested as part of this program are shown in Tables 1 and 2. These host sites reflect a combination of coals and existing air pollution control configurations representing 78% of existing coal-fired generating plants and, potentially, a significant portion of new plants. These host sites will allow documentation of sorbent performance on the following configurations:

**Table 2. Host Sites Participating in the Sorbent Injection Demonstration Project.**

| | **Coal/Options** | **APC** | **Capacity MW/ Test Portion** | **Current Hg Removal (%)** |
|---|---|---|---|---|
| Sunflower Electric's **Holcomb Station** | PRB and Blend | SDA – Fabric Filter | 360/180 and 360/360 | <15 |
| AmerenUE's **Meramec Station** | PRB | ESP | 140/70 | 15–30 |
| American Electric Power's (AEP) **Conesville Station** | Bituminous Blend | ESP + Wet FGD | 400/400 | ~50 |
| Detroit Edison's **Monroe Power Plant** | PRB/Bit Blend | SCR + ESP | 785/196 | 10–30 |
| Missouri Basin Power Project's **Laramie River Station** | PRB | SDA – ESP | 550/140 | <20 |

During the eleventh reporting period, April through June 2006, progress on the project was made in the following areas:

**DTE Energy, Monroe**

- Revisions made to topical report

**AEP, Conesville**

- Continued parametric testing

# EXPERIMENTAL

The overall objective of this test program is to evaluate the capabilities of activated carbon injection at five plants with configurations that together represent 78% of the existing coal-fired generation plants. ADA-ES and the project team will evaluate activated carbon and other viable sorbents on a variety of coals and plant configurations, and perform long-term testing at the optimum condition for up to six weeks. The technical approach is outlined in a series of four technical tasks.

## Task 1. Design and Fabrication of Sorbent Injection System

ADA-ES, the primary test contractor, will provide the majority of the process equipment that will travel from site to site. This equipment is sized and designed to cover the expected range of plant sizes (70–800 MW) and flue gas conditions, and has the flexibility for both baghouse and ESP applications.

## Task 2. Site-Specific Activities Including Field-Testing

This task has seven subtasks. All subtasks will be repeated at each host site, except long-term testing which was not conducted at Laramie River Station. A summary of these subtasks is presented in Table 3. The five sites identified for testing are Sunflower Electric's Holcomb Station, AmerenUE's Meramec Station, Missouri Basin Power Project's Laramie River Station, Detroit Edison's Monroe Power Plant, and AEP's Conesville Station. Testing at Laramie River Station was limited to baseline and a short-term series of parametric tests. Initial screening tests were conducted at Conesville during this quarter. Descriptions of Holcomb, Meramec, Laramie River, and Monroe Station were included in previous quarterly reports. A description of Conesville Station was included in the 4Q05 report. A brief summary is included with the field-testing results for reference.

**Table 3. Task 2 Subtasks (to be repeated at each test site).**

| Subtask | Description |
|---|---|
| 2.1 | Host site kickoff meeting, Test Plan, and QA/QC plan |
| 2.2 | Design and install site-specific equipment |
| 2.3 | Field-tests |
| 2.3.1 | Sorbent selection |
| 2.3.2 | Sample and data coordination |
| 2.3.3 | Baseline tests |
| 2.3.4 | Parametric tests |
| 2.3.5 | Long-term tests<br>*(no long-term tests conducted at Laramie River)* |
| 2.4 | Data analysis |
| 2.5 | Sample evaluation |
| 2.6 | Economic analysis |
| 2.7 | Site (topical) report |

## Subtask 2.1. Host Site Planning and Coordination

Efforts within this subtask include planning the site-specific tests with the host site utility, DOE/NETL, and contributing team members. The planning process includes meeting with plant, corporate, and environmental personnel to discuss and agree upon the overall scope of the program, the potential impact on plant equipment and operation, and to gather preliminary information necessary to develop a detailed draft Test Plan and scope of work. Efforts include identifying any permit requirements, developing a quality assurance/quality control plan, finalizing the site-specific scope for each of the team members, and putting subcontracts in place for manual flue gas measurements, including Ontario Hydro mercury measurement services.

Conesville testing began with baseline tests during 1Q06. REI completed the flow model of the ESP inlet in 4Q05. Data from the flow model was used to design the injection lances.

## Subtask 2.2. Design, Fabricate, and Install Equipment

During this subtask, equipment was identified, designed, fabricated when necessary, and installed at the host site. Some components are site-specific such as the sorbent distribution manifold and sorbent injectors (if possible, these components will be reused at multiple sites). This equipment must be sized, designed, and fabricated for the specific plant arrangements and ductwork configurations. Required site support includes installation of the injection and sampling ports (if not available), installation of required platforms and scaffolding, compressed air, electrical power, wiring plant signals including boiler load to the injection skid and control trailer, and the balance-of-plant engineering.

## Subtask 2.3. Field-Testing

Field-tests are accomplished through a series of five steps. A summary of these steps is presented below.

### *2.3.1 Sorbent Selection*

A key component of the planning process for these evaluations is identifying potential sorbents for testing. To assist in the sorbent selection process, a sorbent screening device (SSD) designed by ADA-ES was used at each site except Laramie River to compare the performance of candidate sorbents. A description of the device used at Holcomb and Meramec was included in the 2Q04 quarterly report. The device used at Monroe and Conesville was described in the 4Q05 quarterly report.

### *2.3.2 Sample and Data Coordination*

ADA-ES engineers coordinate with plant personnel to retrieve the necessary plant operating data files and determine appropriate samples to collect during baseline, parametric, and long-term testing periods. Samples are collected based upon a Sample and Data Management Plan developed for the sites. An example of the sampling schedule for Meramec and additional descriptions of the sample management protocol were included in the 2Q04 quarterly report.

### *2.3.3 Baseline Testing*

Baseline mercury measurements, consisting of Ontario Hydro testing in conjunction with SCEM measurement, are typically made at each site for at least one week prior to beginning parametric mercury control tests. Baseline SCEM measurements were made at Holcomb, Meramec, Laramie, and Monroe. Baseline CEM measurements were conducted this quarter at Conesville. During testing at Laramie River Station, sorbent traps were used for comparison tests with the SCEMs. Ontario Hydro sampling and additional tests, such as EPA M26a or EPA M29 measurements, have also been conducted at Holcomb, Meramec, and Monroe, as well as Conesville.

### *2.3.4 Parametric Testing*

A series of parametric tests is conducted at each site to determine the optimum operating conditions for several levels of mercury control. Evaluations of NORIT's DARCO® Hg and other sorbents chosen by the test team are typically included. Additional tests, such as coal blending or the introduction of additives onto the coal, may also be included.

### *2.3.5 Long-Term Testing*

Thirty-day "long-term" testing has been completed at Holcomb, Meramec, and Monroe. Some long-term tests are planned for Conesville. The matrix is being revised based on current site results, and will be finalized next quarter. The sorbents used during the long-term test period are chosen by the test team based upon performance during parametric testing and a review of the material costs and availability. The goal of the 30-day test phase is to obtain operational data on mercury removal efficiency, the effects on the particulate control device, effects on byproducts and impacts to the balance-of-plant equipment, to prove viability of the process, and determine the economics. During these tests, Ontario Hydro measurements are conducted at the inlet and outlet of the particulate control device at least once.

## Subtask 2.4. Data Analysis

Data collection and analysis for this program are designed to measure the effect of sorbent injection on mercury control and the impact on the existing pollution control equipment. The mercury levels and plant operation are characterized without sorbent injection, during coal blending or coal additive testing, and with various injection rates and possible combustion modifications, as defined by the final Site Test Plan.

## Subtask 2.5. Coal and Byproduct Evaluation

Coal and combustion byproduct samples collected throughout the program are analyzed in this task. During all field test phases, samples of coal and fly ash are collected. At a minimum, ultimate and proximate analyses will be performed and mercury, chlorine, and sulfur levels will be determined in a representative set of the coal samples. Activated carbon injection will result in the fly ash and scrubber materials being mixed with a certain amount of the mercury-containing sorbent. The ash samples will be analyzed at a minimum for mercury and LOI. It is expected that more than 100 samples will be collected at each site. A subset of these samples will be analyzed.

### Subtask 2.6. Economic Analysis

After completion of testing and analysis of the data at each plant, the requirements and costs for full-scale permanent commercial implementation of the selected mercury control technology will be determined. The program team will meet with the host utility plant and engineering personnel to develop plant-specific design criteria. Process equipment will be sized and designed based on test results and the plant-specific requirements (reagent storage capacity, plant arrangement, retrofit issues, winterization, controls interface, etc.). A conceptual design document will be developed. Finally, a budget cost estimate will be developed to implement the control technology.

### Subtask 2.7. Site (Topical) Report

A site (topical) report will be prepared documenting measurements, test procedures, analyses, and results obtained in Task 2. This report is intended to be a stand-alone document providing a comprehensive review of the testing that will be submitted to the host utility. This quarter the site report was completed in draft form for Monroe, and it was submitted to the team for review and comment.

## Task 3. Technology Transfer

Technology transfer activities include participation in DOE/NETL-sponsored meetings, presentations at conferences, and publication of technical papers.

## Task 4. Program Management and Reporting

The final task provides time for overall program management and time to complete DOE's reporting requirements. This task will also support periodic meetings with DOE to discuss progress and obtain overall direction of the program from the DOE project manager. In addition to the standard financial and technical reports, additional deliverables will include topical reports for each site tested. The Project Schedule and Milestones are presented in Table 4.

**Table 4. Project Schedule and Milestones.**

| Activity | Holcomb | | Meramec | | Laramie River | | Monroe | | Conesville | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Target Date | Actual Date | Target Date | Actual Date | Target Date | Actual Date | Target Date | Actual Date | Target Date | Actual Date |
| Site Kickoff Meeting | 3Q03 | 12/16/03 | 2Q04 | 4/20/04 | 1Q05 | 1/20/05 | 4Q04 | 1/11/05 | 2Q05 | 3/1/05 |
| Initiate Parametric Testing | 2Q04 | 5/22/04 | 3Q04 | 8/30/04 | 2Q05 | 2/21/05 | 3Q05 | 3/22/05 | 1Q06 | 3/13/06 |
| Complete Parametric Testing | 2Q04 | 6/11/04 | 4Q04 | 9/27/04 | 2Q05 | 3/8/05 | 3Q05 | 5/26/05 | 2Q06 | |
| Initiate Long-Term Testing | 3Q04 | 7/7/04 | 4Q04 | 10/14/04 | NA | NA | 3Q05 | 6/1/05 | 2Q06 | |
| Complete Long-Term Test | 3Q04 | 8/6/04 | 4Q04 | 11/17/04 | NA | NA | 4Q05 | 7/1/05 | 2Q06 | |
| Complete Site (Topical) Report | 2Q05 | 6/27/05 | 3Q05 | 9/30/05 | 1Q06 | 1/16/06 | 1Q06 | * | 4Q06 | |

** Draft in review (3/31/06)*

There are more than 100 individual team members from 27 organizations participating in this program. Current project co-funding is provided by:

- ADA-ES, Inc.
- ALSTOM
- AmerenUE*
- American Electric Power*
- Arch Coal
- Detroit Edison*
- Dynegy Generation
- EPRI
- MidAmerican
- NORIT Americas
- Ontario Power Generation and partners
  - EPCOR
  - Babcock & Wilcox
- Southern Company
- Sunflower Electric Power Corporation* and partners
  - Associated Electric Coop
  - City of Sikeston
  - Empire District Electric Company
  - Kansas City Board of Public Utilities (KCKBPU)
  - Kansas City Power and Light
  - Kennecott Coal
  - Missouri Basin Power Project*
  - Nebraska Public Power District
  - PacifiCorp
  - Peabody Coal
  - Southern Minnesota Municipal Power Agency
  - Tri-State Generation & Transmission
  - TransAlta Utilities
  - TransAlta Energy.
  - Westar Energy
  - Western Fuels Association
  - Wisconsin Public Service
- Tennessee Valley Authority

** Indicates host site*

Key members of the test team include:

ADA-ES, Inc.

Project Manager: Sharon Sjostrom

Site Manager (Holcomb, Meramec, Laramie River, Monroe): Travis Starns

Site Manager (Conesville): Cody Wilson

SCEM/CEM Lead: Jerry Amrhein

DOE/NETL

Project Manager: Andrew O'Palko

EPRI

Project Manager: Ramsay Chang

Reaction Engineering International

Coal and byproduct analysis interpretation, flow modeling for Conesville: Connie Senior

ALSTOM

Scrubber operation for Holcomb and Laramie River and KNX coal additive injection parameters: Leif Lindau

To facilitate information sharing, a project website is maintained for the project. The project website is password protected and available only to project participants. Information available through the website includes all presentations, papers, reports, planning documents, schedules, and other information related to the project.

A schedule showing field-tests planned and completed at each test site is shown in Table 5.

**Table 5. Field-Testing Schedule.**

| **Site** | **2004** | | | **2005** | | | | **2007** | |
|---|---|---|---|---|---|---|---|---|---|
| | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** |
| Holcomb | | | | | | | | | |
| Meramec | | | | | | | | | |
| Laramie River | | | | | | | | | |
| Monroe | | | | | | | | | |
| Conesville Spring '06 | | | | | | | | | |

# RESULTS AND DISCUSSION

## Task 1. Design and Fabrication of Sorbent Injection System

Design and fabrication of the sorbent injection system used at Holcomb, Meramec, Monroe, and Conesville Station was completed during the January–March 2004 reporting period.

## Task 2. Site-Specific Activities Including Field-Testing

Full-scale testing at Conesville began in 1Q06.

Sorbent screening tests were conducted in 4Q05, 1Q06, and 2Q06. Results from these tests were used to identify appropriate sorbents for full-scale testing. Preliminary results from the sorbent screening tests and modeling efforts are included under this heading.

Sorbent screening tests and parametric tests were conducted this quarter. Preliminary field results are included in this section.

### Subtask 2.1. Host Site Planning and Coordination

Detailed planning and coordination activities for Conesville were conducted this quarter. Weekly meetings were conducted during field-testing.

### Subtask 2.2. Design, Fabricate, and Install Equipment

Modeling of PAC injection into the ESP at Conesville was completed and reported in 4Q05.

### Subtask 2.3. Field-Testing

#### *2.3.1 Sorbent Selection*

Additional sorbent screening tests were conducted this quarter in an effort to identify materials effective in this difficult flue gas. Results from screening tests are being reviewed and will be included in the 3Q06 report.

#### *2.3.2 Sample and Data Coordination*

The Test Plan and Sample Management Plan for Conesville were finalized during 1Q06.

#### *2.3.3 Baseline Testing*

Baseline tests were completed during 1Q06.

### *2.3.4 Parametric Testing Results*

**Mercury Removal**

Four weeks of parametric testing were conducted: March 21–24, March 27–31, May 8–12, and May 15–19, 2006. The sorbents tested are shown in Table 6. Seven DARCO® E-series sorbents were included (12, 13, 14, 15, 18, 19, and 20). The DARCO® E-series products included mixes of alkali with carbon, other substrates (e.g., non coal-based carbon), and other mixes of sorbents and materials that may protect the sorbents from $SO_3$. Several of these materials were produced by NORIT at the request of the test team.

**Table 6. Sorbents Included in Full-Scale Injection "Screening" Tests at Conesville.**

| Sorbent |
|---|
| Calgon RUV-N and RUV+ |
| Sorbent Technologies EXP-2 |
| Donau DESOREX® DX700C |
| NORIT DARCO® Hg |
| NORIT DARCO® Hg-LH |
| NORIT DARCO® E-xx |
| NORIT Insul |
| EERC C5SL |

The parametric tests consisted of "screening" the sorbents by injecting at the maximum achievable continuous feed rate of the injection system for 2 to 3 hours. Due to difficulties controlling the feed rate, the actual injection concentrations ranged from 9 to 18 lb/MMacf from sorbent to sorbent during the first two weeks of testing. The problems with the feeder were resolved during the second week of testing and all subsequent tests were conducted at an injection concentration of 8 lb/MMacf. During the final two weeks of parametric testing, two different lance designs were tested to evaluate the impact on mercury removal.

The effectiveness of the sorbents tested was limited, with mercury removal ranging from 5 to 31% at injection concentrations up to 18 lb/MMacf. The maximum incremental removal by a sorbent was 31% (DARCO® E-12 at 12 lb/MMacf). The next-highest removal was 25% (Sorbent Technologies EXP-2 at 10 lb/MMacf). Although the injection concentrations varied, the results indicate that none of the sorbents was able to achieve the minimum project mercury removal goal of 50% at an injection concentration below 10 lb/MMacf. A summary of the results is presented in Figure 1. During several later tests, an alternative lance configuration was used that treated only the B-side of the duct. An example of the mercury trend graphs during the second week of parametric testing is shown in Figure 2.

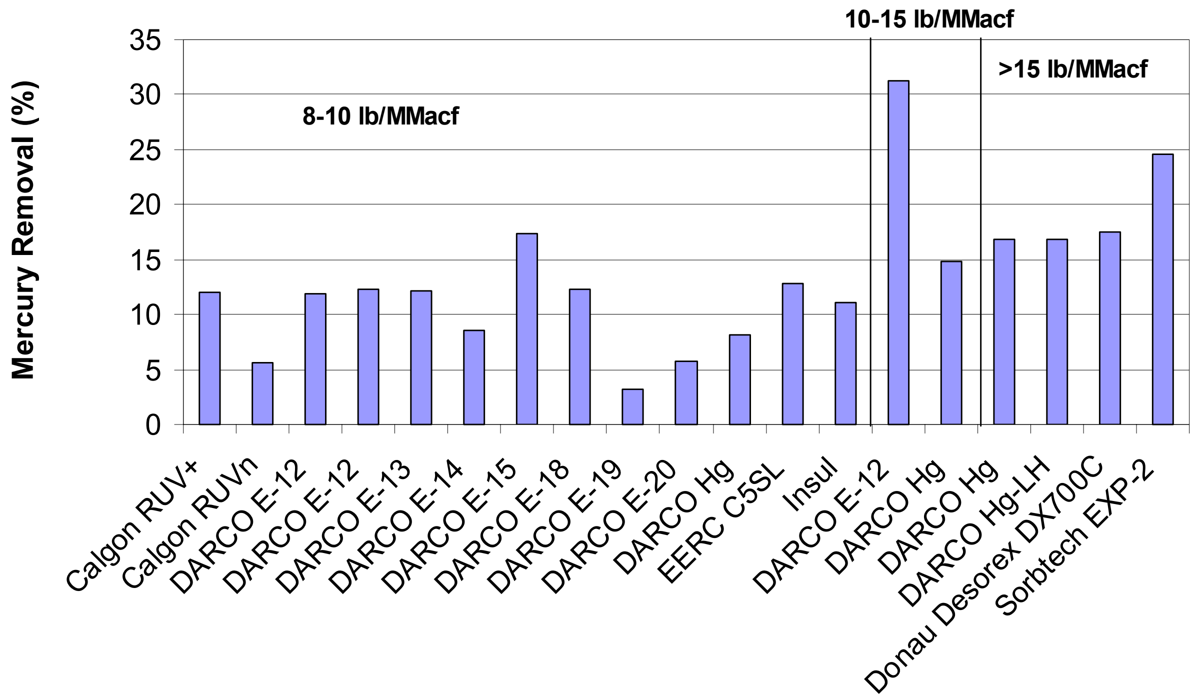


**Figure 1. Summary of Short Screening Test Results.**

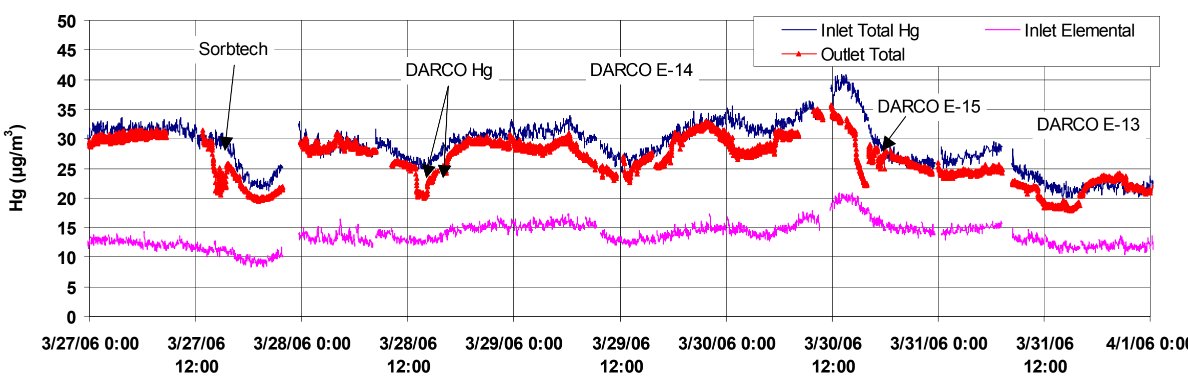


**Figure 2. Mercury Trend Graph during Parametric Test Week 2.**

## Sorbent Distribution

Sorbent distribution modeling was included in the plans for Conesville because of the number of turning vanes in the inlet ductwork. Additional modeling and stratification measurements were conducted to assure the test team that the poor mercury removal measured was a function of the sorbent properties and not the distribution grid.

The Computational Fluid Dynamics (CFD) modeling indicated that the sorbent was fairly well distributed across the ESP inlet duct at Conesville if 10 of the 12 injection ports were used. During all injection tests with multi-nozzle lances, the recommended 10 ports were utilized. A sketch of the multi-nozzle lance arrangement is shown in Figure 3. Several tests were conducted with single-nozzle lances. This arrangement, which treated the B-side of the ESP only, is shown in Figure 4. Sorbent trap method (STM) measurements were made across the outlet duct to determine if stratification in mercury removal was occurring.

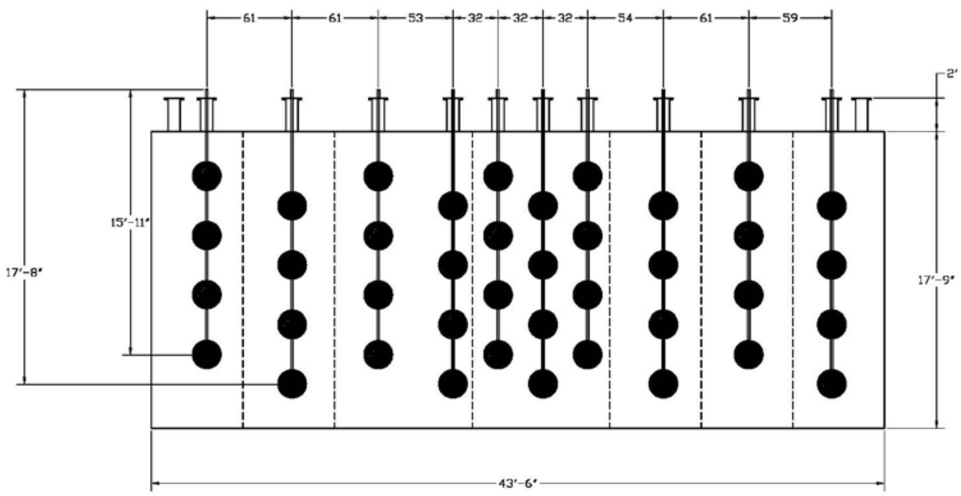


**Figure 3. Multi-Nozzle Lance Arrangement.**

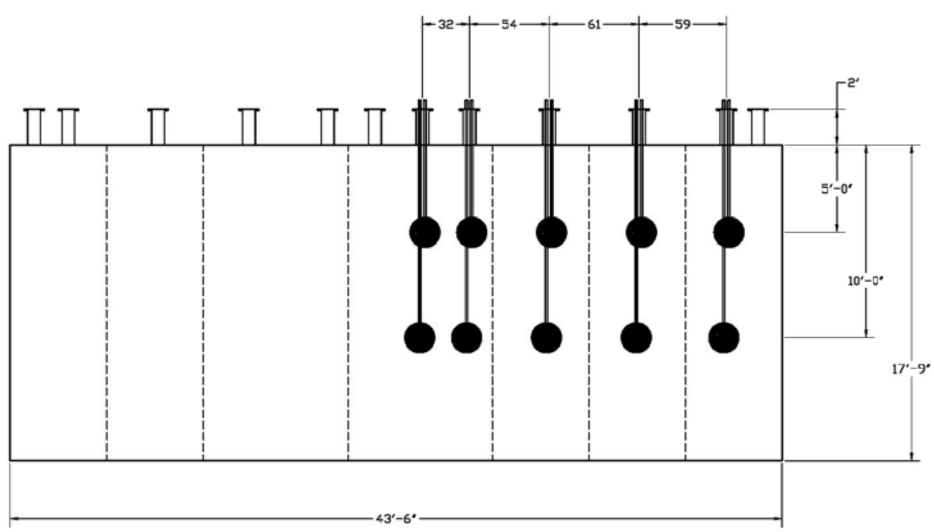


**Figure 4. Single-Nozzle Lance Arrangement.**

STM measurements were conducted simultaneously across the duct at two depths with two traps per duct. Results from STM analysis indicate that, other than one outlier, there was no indication of sorbent stratification at the outlet of the ESP using either the multi- or single-nozzle lance arrangement. These results are presented in Figures 5 and 6.

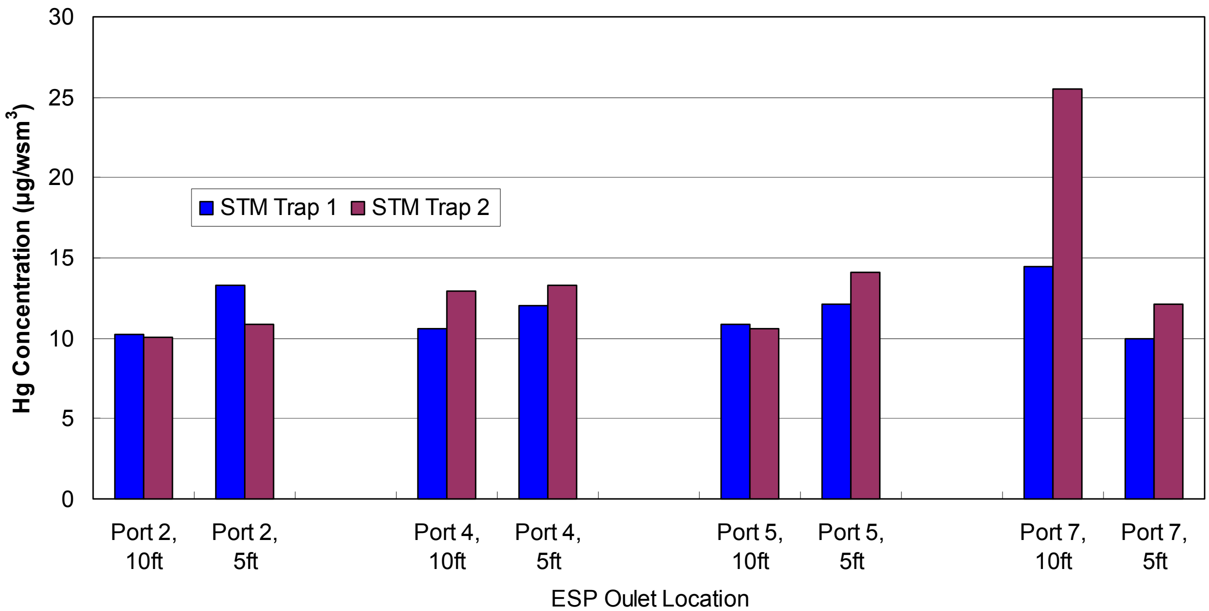


**Figure 5. STM Measurements with Multi-Nozzle Lance Arrangement.**

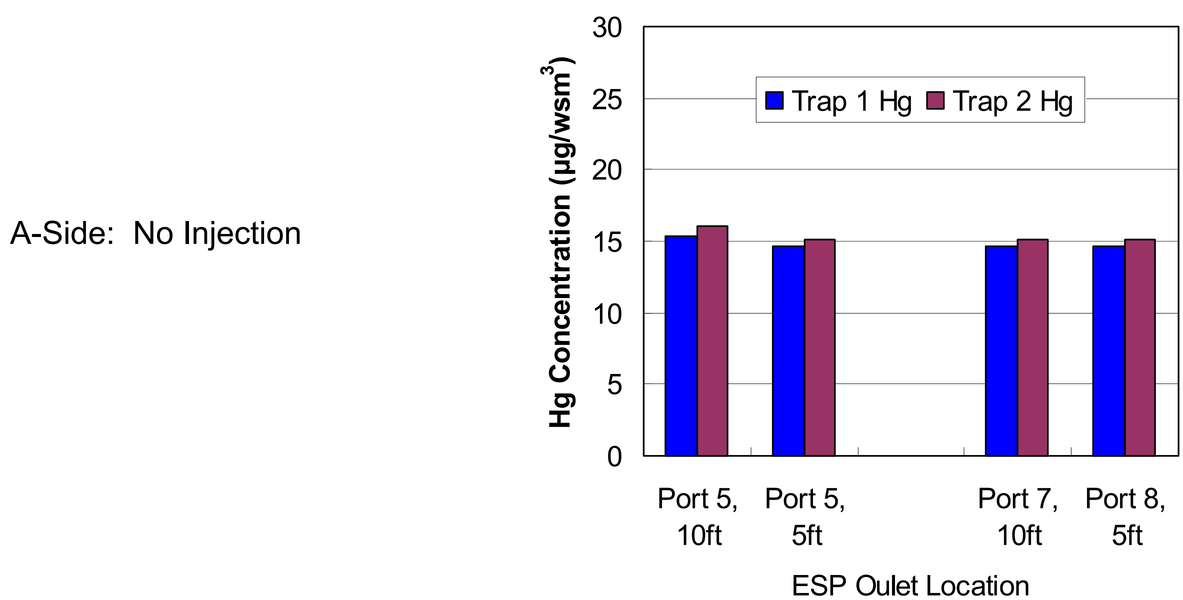


**Figure 6. STM Measurements with Single-Nozzle Lance Arrangement.**

REI carried the CFD model to the next level by incorporating equilibrium adsorption characteristics in with the predicted sorbent loading. Equilibrium characteristics of DARCO® Hg that were measured at Conesville with the fixed-bed screening apparatus were incorporated into REI's model. The results of the model predicted 9 to 22% mercury removal if DARCO® Hg were injected at 10 lb/MMacf, depending upon the reactivity of the sorbent. Injection tests at 9.5 lb/MMacf of DARCO® Hg resulted in 8% mercury removal. The model predicted nominally 6 to 13% less removal at the hottest portion of the duct compared to the coolest, depending on the reactivity of the sorbent. The STM stratification measurements presented in Figures 5 and 6 indicate the mercury removal on the warmer B-side was equivalent to the cooler A-side. Mercury stratification was measured in the inlet-field hopper samples, but the concentrations were within the range measured during baseline testing.

## Impact on ESP

ESP performance was affected by some sorbents, in terms of spark rates and power. Opacity spikes were also noted during some tests, which may have been attributable to sorbents or to normal unit operational variations. The spark rate increase was significant for some sorbents at injection concentrations below 10 lb/MMacf, such as DARCO® E-15 and E-18. Injecting DARCO® E-12 at 12 lb/MMacf resulted in an increased spark rate on the B-side of the ESP four times above baseline levels. In most cases, the impact of the sorbent was greater on the B-side (warmer side) of the ESP. These results are presented in Figure 7.

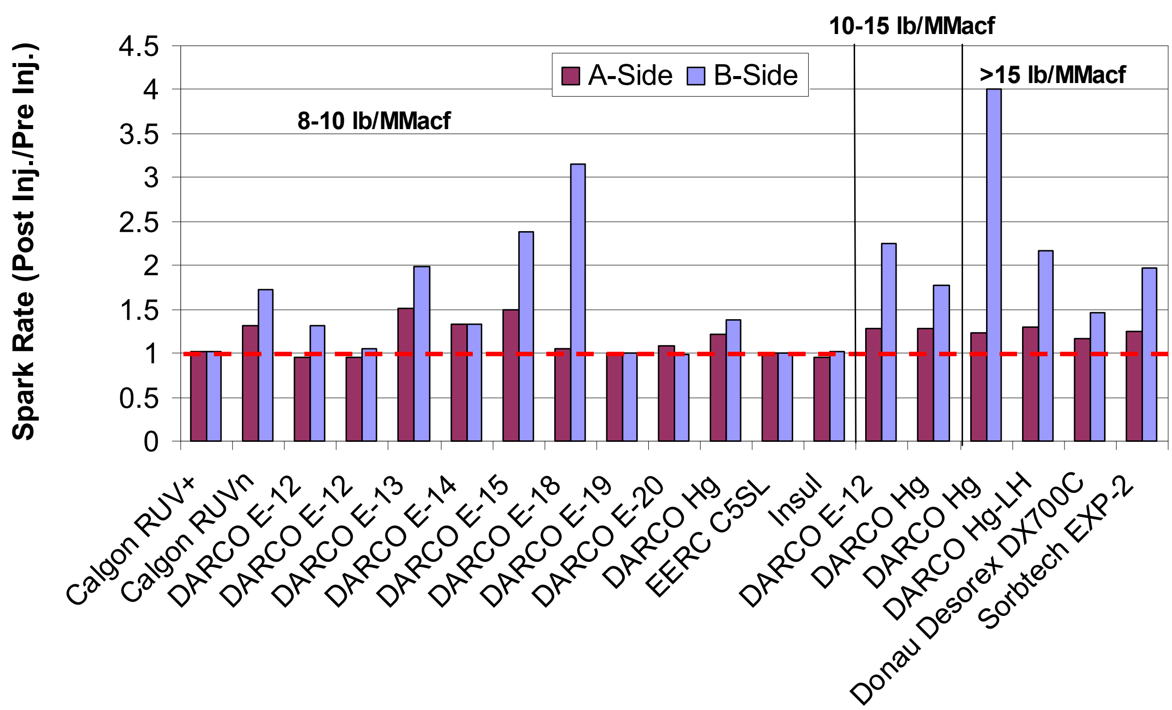


**Figure 7. Impact of Sorbent Injection on Spark Rate.**

Average opacity did not change when injecting any sorbent, except DARCO® E-12. This sorbent increased the B-side opacity by over 4% while injecting 12 lb/MMacf into the ESP. These results are presented in Figure 8. Although the average opacity was not changed, the maximum opacity spikes increased significantly for several materials, especially when injecting these materials at concentrations greater than 10 lb/MMacf.

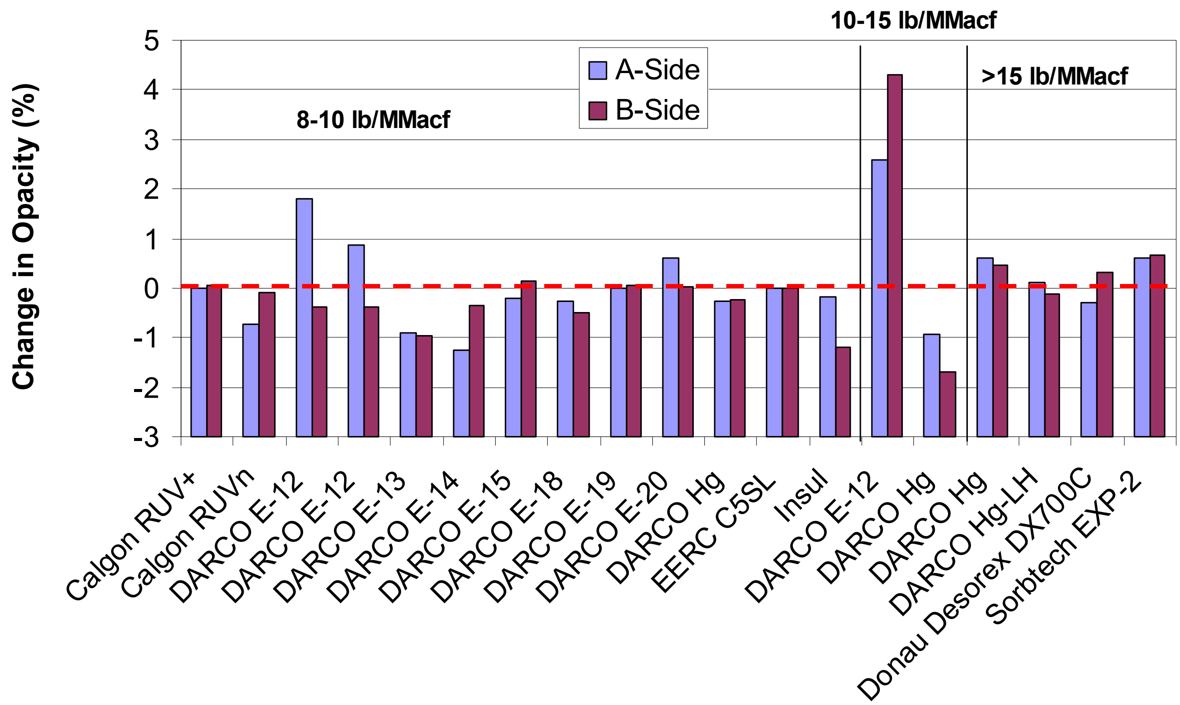


**Figure 8. Change in ESP Outlet Opacity due to Sorbent Injection.**

### *2.3.5 Long-Term Testing*

No activities this period.

## <u>Subtask 2.4. Data Analysis</u>

Data collected from Conesville Power Plant are currently being reviewed.

## <u>Subtask 2.5. Coal and Byproduct Evaluation</u>

Hundreds of samples are typically collected from each test site. Most of the ash samples, several coal samples, and at least one of all other sample types will be analyzed for mercury. Samples collected from Conesville include coal, ash from multiple hoppers, and WFGD samples (feed slurry, lime, recycled water, etc.). Additional analyses, including coal ultimate and proximate analyses, and coal and ash chlorine analyses, are being conducted. Results from Holcomb, Laramie River, and Meramec are available in the respective topical report for each site. The topical report for Monroe is scheduled to be issued soon.

# CONCLUSIONS

Field-testing has been completed at Holcomb, Meramec, Laramie River, and Monroe Stations. Topical reports are available for Holcomb, Meramec, and Laramie River. The topical report for Monroe has been issued in draft form this quarter for review and comment by the team.

The flue gas at Conesville has proven to be challenging for all sorbents tested to date at the site. Based upon these results, none of these materials warrants further testing at Conesville.

In general, the results indicate that:

- ESP native mercury capture is very low at Conesville, from 0 to 20%. The mercury is 60–70% oxidized at the ESP outlet, upstream of the WFGD, and 90% elemental at the WFGD outlet.
- Most of the oxidized mercury is removed in the WFGD.
- Mercury ranges from 13 to 33 lb/TBtu at the ESP (baseline results).
- Most, but not all, sorbents increased T/R set spark rates or impacted opacity spikes.
- The maximum incremental removal by a sorbent was 31% (DARCO® E-12 at 12 lb/MMacf). The next-highest removal was 25% (Sorbent Technologies EXP-2 at 10 lb/MMacf).
- All other sorbents tested yielded <20% incremental mercury capture.
- The mercury CEM installed at Conesville has demonstrated extended, unattended operation with fairly reliable performance.

The challenges identified and characterized at Conesville may represent a much larger hurdle to mercury control for the industry than high sulfur units alone. The presence of $SO_3$ in flue gas appears to decrease mercury capture by activated carbon, sometimes dramatically. $SO_3$ may be present in sufficiently high concentrations in several common configurations including low sulfur units using $SO_3$ for flue gas conditioning and units with SCRs where the SCR is converting sufficient $SO_2$ to $SO_3$. Although sorbents tested at Conesville did not show significant mercury removal, they have demonstrated tolerance to $SO_3$ and many may be applicable to other configurations with lower flue gas $SO_2$ or $SO_3$ concentrations.

The goal of this DOE program is to achieve 50 to 70% mercury capture. Because this goal has not been reached at Conesville, early next quarter the team will be reviewing data and a recommended revision to the test matrix. Alternate sorbents will be evaluated during extended parametric testing followed by long-term testing if the goals established by DOE can be achieved.

# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ACI | Activated carbon injection |
| APC | Air pollution control |
| B&W | Babcock & Wilcox |
| CFD | Computational Fluid Dynamics |
| COC | Chain of Custody |
| DARCO® Hg | Sorbent manufactured by NORIT Americas. Formerly known as DARCO® FGD |
| DARCO® Hg-LH | Sorbent manufactured by NORIT Americas. Formerly known as DARCO® FGD-E3 |
| DOE | Department of Energy |
| ESP | Electrostatic precipitator |
| FGD | Flue gas desulfurization |
| ID Fan | Induced draft fan |
| kacfm | Thousand actual cubic feet per minute |
| kW | Kilowatt |
| MW | Megawatt |
| NETL | National Energy Technology Laboratory |
| O&M | Operating and Maintenance |
| PAC | Powdered activated carbon |
| PC | Pulverized coal |
| PRB | Powder River Basin |
| SCA | Specific collection area |
| SCR | Selective Catalytic Reduction |
| SCEM | Semi-continuous emission monitor |
| SDA | Spray dryer absorber |
| SGLP | Synthetic groundwater leaching procedure |
| SSD | Sorbent screening device |
| STM | Sorbent trap method |
| TCLP | Toxicity characteristic leaching procedure |